Carnation

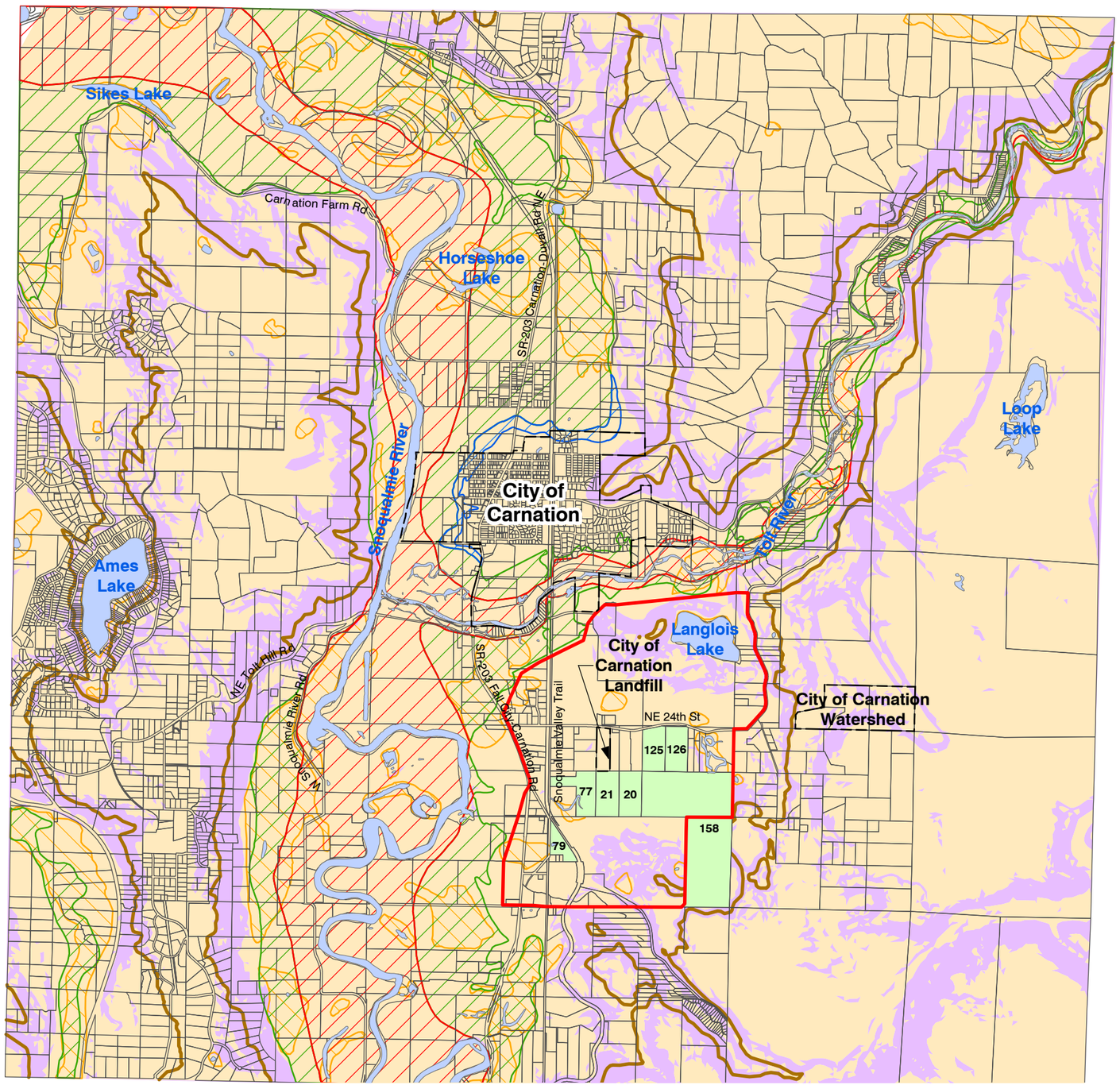
Wastewater Treatment Plant

Appendix C - Upland Discharge Coarse Screening Results and Technical Information

King County

July 2003

V:\Client77\KingCo\6620\car603\SitingProcessSumMemo\Memo.indd



3,500 1,750 0 3,500
Feet

N

LEGEND

- Upland Discharge Study Area (Potentially Suitable Soils For Infiltration)
- Potential Upland Discharge Site
- Water Body
- Wetland

Floodplain

- Floodway
- 500 Year
- 100 Year

Slope

- Slope < 10%
- Slope >10%
- Carnation Boundary
- Parcel Boundary

POTENTIAL UPLAND DISCHARGE SITES BASED ON COARSE SCREENING CRITERIA

CARNATION WASTEWATER TREATMENT FACILITY
KING COUNTY DEPARTMENT OF
NATURAL RESOURCES AND PARKS

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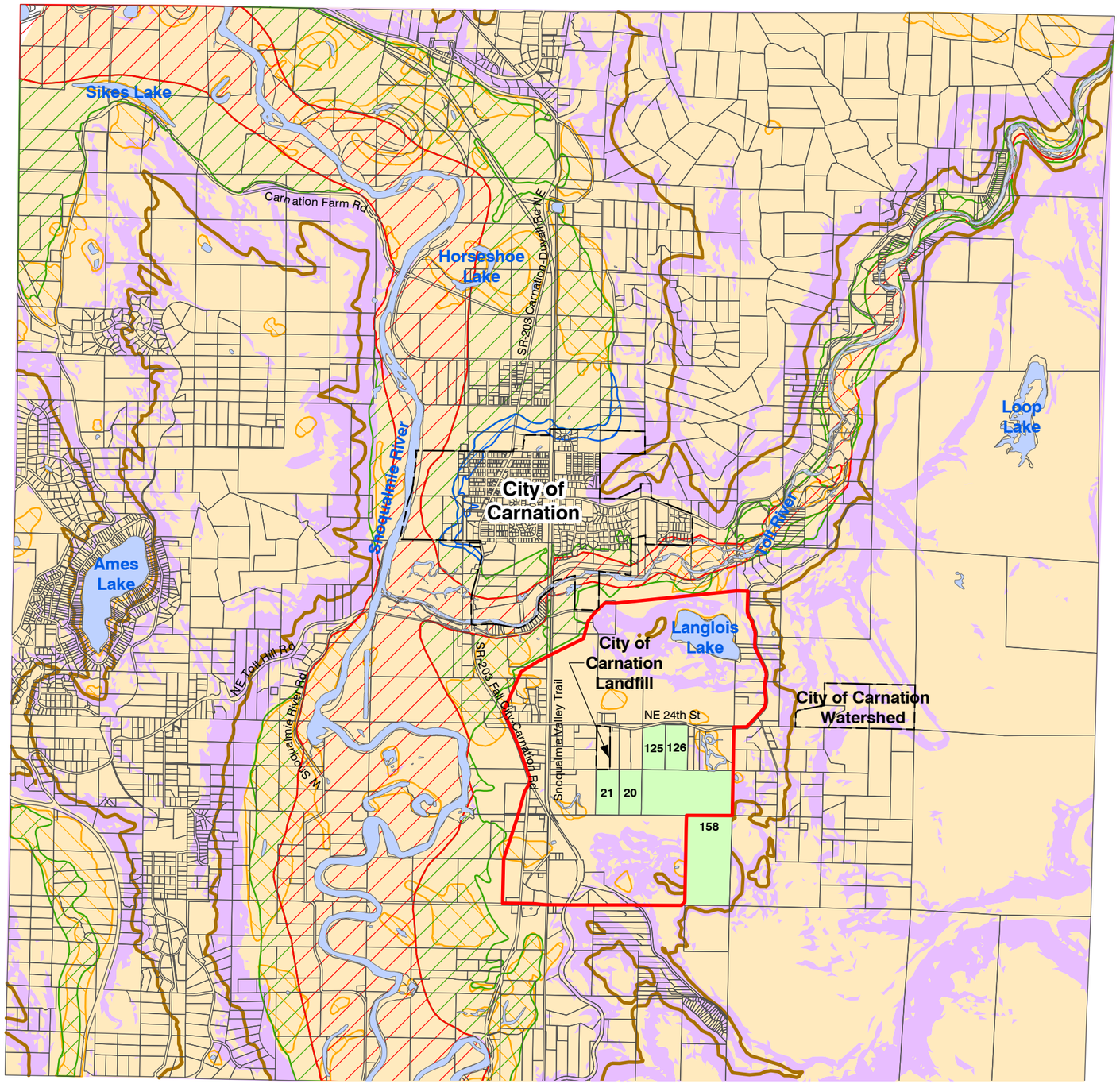
June 27, 2003



3,500 1,750 0 3,500
Feet

N

LEGEND

- Upland Discharge Study Area (Potentially Suitable Soils For Infiltration)
- Potential Upland Discharge Site
- Water Body
- Wetland

Floodplain

- Floodway
- 500 Year
- 100 Year

Slope

- Slope < 10%
- Slope >10%
- Carnation Boundary
- Parcel Boundary

POTENTIAL UPLAND DISCHARGE SITES BASED ON FINE SCREENING CRITERIA

CARNATION WASTEWATER TREATMENT FACILITY
KING COUNTY DEPARTMENT OF
NATURAL RESOURCES AND PARKS

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June 30, 2003

City of Carnation
Upland Discharge Site
Fine Screening Evaluation
DRAFT

CAC Siting Process Issues Highlighted

Low
Medium
High

Subject Group	Characteristic	Questions	Scale	Probable Impacts						
				Site 20	Site 21	Site 77	Site 79	Site 125	Site 126	Site 158 (Weyer-haeuser Site)
Land Use Compatibility and Acquisition	Compatible with surrounding land uses	Does the proposed facility comply with City code allowable uses? Does use preclude higher economic uses?	**High:** Not compatible, precludes economic development							
			Medium: Conditional use or variance required, may affect economic development							
			Low: Compatible, allowed use, no impact on economic development							
	Land use change requirement	What type of land use change will be required to permit the project to be constructed on the site?	**High:** Zoning change required or significant obstacles to obtaining a conditional use permit							
			Medium: Conditional use permit required							
			Low: Allowed use							
	Property easily converted to utility use	Who owns the site and what is it currently used for?	**High:** Occupied private industrial, commercial or residential property, acquisition may delay schedule							
			Medium: Vacant private industrial, commercial or residential property or agricultural land, acquisition will not delay schedule							
			Low: City of Carnation or King County owned property							
	Area and cost of private property acquisition	What is the estimate of area and costs of private property that must be acquired for the project?	**High:** Occupied private industrial, commercial or residential property - acquisition cost based on the value of land and significant improvements.							
			Medium: Vacant private industrial, commercial or residential property or agricultural land - acquisition cost based primarily on land value.							
			Low: Parcel size and value consistent with needs - no cost or already owned.							
			Red	0	0	2	2	2	0	0
			Yellow	3	3	2	2	2	4	4
			Green	1	1	0	0	0	0	0
			Red and Yellow	3	3	4	4	4	4	4
Geographic Location	Visual Impacts	Is the site visible to other uses?	**High:** Visible near businesses or residential areas. Substantial screening required including landscaping and architectural.							
			Medium: Separation from businesses or residential areas. Limited screening required, mainly landscaping.							
			Low: Site in isolated, rural area							
	Traffic disruption	To what extent will facility construction and operation affect traffic?	**High:** No, or inadequate roads, major improvements required for safety or durability							
			Medium: Adequate roads, some improvement needed for safety or durability							
			Low: Roads adequate for traffic volume, loads, safety							
	Separation from other uses	To what extent will facility construction and operation affect adjacent uses or pedestrian circulation?	**High:** Will unavoidably affect adjacent residential or recreational uses and/or pedestrian circulation - mitigation possible.							
			Medium: Will unavoidably affect adjacent commercial or industrial properties - mitigation possible.							
			Low: Will not affect residential uses or commercial, and recreational circulation or uses.							
	Access to infrastructure	Is there adequate access to water, electricity, telephone and other required infrastructure?	**High:** > 2 miles							
			Medium: 1/2 - 2 miles							
			Low: <1/2 miles							
	Flooding	Would the facility be located in an area with known flooding problems?	**High:** Located in designated FEMA 100 year flood plain							
			Medium: Partially located in designated 100 year flood plain							
			Low: Not located in flood plain							
			Red	1	1	0	0	0	0	1
			Yellow	1	1	3	3	2	2	1
			Green	3	3	2	2	3	3	3
			Red and Yellow	2	2	3	3	2	2	2

City of Carnation
Upland Discharge Site
Fine Screening Evaluation
DRAFT

CAC Siting Process Issues Highlighted

Low
Medium
High

Subject Group	Characteristic	Questions	Scale	Site 20	Site 21	Site 77	Site 79	Site 125	Site 126	Site 158 (Weyer-haeuser Site)
				Probable Impacts						
Technical Feasibility	Area Size and Shape	Is the size of the useable area adequate to allow flexibility for design, projected expansion, and long-term operation? Does the shape of the useable area allow for efficient arrangement, support facilities, and projected future expansions?	**High:** Size and shape substantially limits flexibility for design, expansion, and operation							
			Medium: Size and shape adequate and provides moderate level of flexibility							
			Low: Size and shape ample for long-term use.							
	Groundwater Level	Does the groundwater impact use of the site or increase construction costs?	**High:** < 5 ft from surface							
			Medium: 5 - 20 ft from surface							
			Low: > 20 ft from surface							
	Presence of Contamination	Are contaminated soils and/or groundwater present within the site and conveyance areas?	**High:** Presence of known/documented contamination at usable portion of site that prevent or deter mitigation.							
			Medium: Presence of known contamination that allows use without disturbance							
			Low: No documented contamination on site							
			Red	0	0	0	0	0	0	0
			Yellow	1	1	1	2	1	1	1
			Green	2	2	2	1	2	2	2
			Red and Yellow	1	1	1	2	1	1	1
Environmental Impacts	Shoreline Management	Does the site or the conveyance system lie within the Shoreline Management Zones of either the City of Carnation or King County?	**High:** The site and conveyance system are within 200 ft of the shorelines of lakes, rivers or streams							
			Medium: The site or conveyance system are within 200 ft of the shorelines of lakes, rivers or streams							
			Low: The site and conveyance system are not within 200 ft of the shorelines of lakes, rivers or streams							
	Sensitive Areas, Wetlands, Wetland Buffer, Stream, and/or Stream Buffer Impacts	Will construction of the proposed facilities or conveyance system disturb any of the designated sensitive areas of the City of Carnation or King County?	**High:** The site or conveyance system disturb sensitive areas of both of the listed jurisdictions							
			Medium: The site or conveyance system disturb sensitive areas of one listed jurisdiction							
			Low: The site and conveyance system do not disturb sensitive areas of the listed jurisdictions							
	Endangered Species	Would proposed site and conveyance system affect threatened/endangered/candidate species habitat?	**High:** Facility footprint may unavoidably result in direct modification or elimination of habitat important/unique to listed and/or threatened/endangered/candidate species.							
			Medium: Facility footprint may result in unavoidable impacts to buffer of listed threatened/endangered/candidate species.							
			Low: Facility footprint would result in minimal impacts to listed threatened/endangered/candidate species.							
	Wells	Would the facility footprint require additional mitigation measures to protect a potable public water system?	**High:** Facility footprint would fall within 1000-ft of a potable water supply well							
			Medium: Facility footprint would fall within 2,000-ft a potable water supply well							
			Low: No potable water supply wells within 2,000 ft.							
			Red	1	1	1	1	1	1	0
			Yellow	0	0	0	0	0	0	1
			Green	3	3	3	3	3	3	3
			Red and Yellow	1	1	1	1	1	1	1
			Total Red	2	2	3	3	3	1	1
			Total Yellow	5	5	6	7	5	7	7
			Total Green	9	9	7	6	8	8	8
			Total Red and Yellow	7	7	9	10	8	8	8
			Upland Discharge Site Rank							

Upland Discharge
Site Fact Sheet
Option A
(Site No. 20)

Overall Site Description

- Located southeast of the City of Carnation in unincorporated King County. It is directly south of the closed City landfill.
- There are no access roads to the site. The closest current roads are NE 24th Street and NE 20th Street.
- The site has a slight slope to the south and includes second growth trees.

Screening Summary and Results

- The site ranked relatively high for *Land Use Compatibility and Acquisition* since:
  - The site is privately owned and is currently undeveloped second growth forest. There is sufficient space for upland disposal facilities.
- The site ranked slightly lower for *Geographic Location* since:
  - The site is in an isolated, rural area and is not visible to nearby residences. Therefore, substantial screening or architectural treatment is probably not required.
  - However, the existing access roads are inadequate. Major improvements would be required for construction and operation of the facility.
- The site is in the area with the highest probability of soils good for infiltration. The remaining screening criteria are similar to other potential sites for *Technical Feasibility*.
- The site is similar to other potential sites for *Environmental Impacts* based on fine screening.

RECOMMENDATION:
Continue Evaluation in System Alternative Phase

Site Characteristics

Land Use and Acquisition

- The site is privately owned and is currently undeveloped second growth forest. There is sufficient space for upland disposal facilities.
- The site is zoned Rural Area, Residential. A Special Use Permit is required if upland discharge of treatment plant effluent is defined as a wastewater treatment plant function. Development of upland discharge facilities is unlikely to affect economic development of the site.

Geographic Location

- The site is in an isolated, rural area and is not visible to nearby residences. Therefore, substantial screening or architectural treatment is probably not required.
- The existing access roads to the site are inadequate. Major improvements would be required for construction and operation of the facility.
- Infrastructure such as electricity and water is not readily available at the site and would need to routed from the nearest available location.

Technical Feasibility

- There is no known contamination on the site.

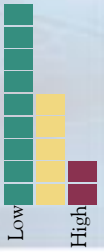
Environmental Impacts

- There are no known impacts to shorelines, sensitive areas, wetlands or endangered species at this time. Additional information should be collected to determine if there are any potential environmental impacts.
- Depending on the exact location of the facility, the footprint may fall within 1,000 feet of a water well. Additional mitigation measures may be required to protect the well.

SITE SUMMARY

Geographic Location: Unincorporated King County (Southeast of City of Carnation)
Estimated Total Area: 20.1 acres
Owner: Private Property
Current Use: Vacant

Fine Screening Impact Results:



King County

Car603fsSite20-6620.indd 6/30/03

Upland Discharge
Site Fact Sheet
Option B (Site No. 21)

Overall Site Description

- Located southeast of the City of Carnation in unincorporated King County. It is southeast of the closed City landfill.
- There are no access roads to the site. The closest current roads are NE 24th Street and NE 20th Street.
- The site has a slight slope to the south and includes second growth trees.

Screening Summary and Results

- The site ranked relatively high for *Land Use Compatibility and Acquisition* since:
  - The site is privately owned and is currently undeveloped second growth forest. There is sufficient space for upland disposal facilities.
- The site ranked slightly lower for *Geographic Location* since:
  - The site is in an isolated, rural area and is not visible to nearby residences. Therefore, substantial screening or architectural treatment is probably not required.
  - However, the existing access roads are inadequate. Major improvements would be required for construction and operation of the facility.
- The site is in the area with the highest probability of soils good for infiltration. The remaining screening criteria are similar to other potential sites for *Technical Feasibility*.
- The site is similar to other potential sites for *Environmental Impacts* based on fine screening.

RECOMMENDATION:
Continue Evaluation in System Alternative Phase

Site Characteristics

Land Use and Acquisition

- The site is privately owned and is currently undeveloped second growth forest. There is sufficient space for upland disposal facilities.
- The site is zoned Rural Area, Residential. A Special Use Permit is required if upland discharge of treatment plant effluent is defined as a wastewater treatment plant function. Development of upland discharge facilities is unlikely to affect economic development of the site.

Geographic Location

- The site is in an isolated, rural area and is not visible to nearby residences. Therefore, substantial screening or architectural treatment is probably not required.
- The existing access roads to the site are inadequate. Major improvements would be required for construction and operation of the facility.
- Infrastructure such as electricity and water is not readily available at the site and would need to routed from the nearest available location.

Technical Feasibility

- There is no known contamination on the site.

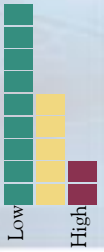
Environmental Impacts

- There are no known impacts to shorelines, sensitive areas, wetlands or endangered species at this time. Additional information should be collected to determine if there are any potential environmental impacts.
- Depending on the exact location of the facility, the footprint may fall within 1,000 feet of a water well. Additional mitigation measures may be required to protect the well.

SITE SUMMARY

Geographic Location: Unincorporated King County (Southeast of City of Carnation)
Estimated Total Area: 20.6 acres
Owner: Private Property
Current Use: Vacant

Fine Screening Impact Results:



King County

Car603fsSite21-6620.indd 6/30/03

Upland Discharge Site Fact Sheet

Option C (Site No. 125)

Overall Site Description

- Located southeast of the City of Carnation in unincorporated King County. It is east of the closed City landfill along NE 24th Street.
- The site has a slight slope to the north and is forested land.
- Improvements on the property include a single-family residence toward the north side of the property.

Screening Summary and Results

- The site ranked slightly lower for *Land Use Compatibility and Acquisition* since:
  - The site is privately owned and currently has a single-family residence.
- The site ranked relatively high for *Geographic Location* since:
  - The site is in an isolated, rural area and is not visible to nearby residences since sufficient buffer is likely available. Therefore, substantial screening or architectural treatment is probably not required.
  - NE 24th Street provides access to the site. Major improvements are not likely required for construction and operation of the facility.
- The site is in the area with the second highest probability of soils good for infiltration. The remaining screening criteria are similar to other potential sites for *Technical Feasibility*.
- The site is similar to other potential sites for *Environmental Impacts* based on fine screening.

RECOMMENDATION:
Continue Evaluation in System Alternative Phase

Site Characteristics

Land Use and Acquisition

- The site is privately owned and currently has a single-family residence with undeveloped forest on the majority of the property. There is sufficient space for upland disposal facilities.
- The site is zoned Rural Area, Residential. A Special Use Permit is required if upland discharge of treatment plant effluent is defined as a wastewater treatment plant function. Development of upland discharge facilities is unlikely to affect economic development of the site.

Geographic Location

- The site is in an isolated, rural area and is not visible to nearby residences since sufficient buffer is likely available. Therefore, substantial screening or architectural treatment is probably not required.
- NE 24th Street provides access to the site. Increased traffic during construction and operation of the treatment plant is expected to have minimal impact on circulation in this area.
- Infrastructure such as electricity and water is not readily available at the site and would need to routed from the nearest available location.

Technical Feasibility

- There is no known contamination on the site.

Environmental Impacts

- There are no known impacts to shorelines, sensitive areas, wetlands or endangered species at this time. Additional information should be collected to determine if there are any potential environmental impacts.
- Depending on the exact location of the facility, the footprint may fall within 1,000 feet of a water well. Additional mitigation measures may be required to protect the well.

SITE SUMMARY

Geographic Location: Unincorporated King County (Southeast of City of Carnation)
Estimated Total Area: 19.8 acres
Owner: Private Property
Current Use: Occupied Single-Family Residential

Fine Screening Impact Results:

King County

Car603fsSite125-6620.indd 6/30/03

Upland Discharge
Site Fact Sheet
Option D
(Site No. 126)

Overall Site Description

- Located southeast of the City of Carnation in unincorporated King County. It is east of the closed City landfill along NE 24th Street.
- The site has a slight slope to the north and is forested land.

Screening Summary and Results

- The site ranked relatively high for *Land Use Compatibility and Acquisition* since:
  - The site is privately owned and is currently undeveloped forest. There is sufficient space for upland disposal facilities.
- The site ranked relatively high for *Geographic Location* since:
  - The site is in an isolated, rural area and is not visible to nearby residences since sufficient buffer is likely available. Therefore, substantial screening or architectural treatment is probably not required.
  - NE 24th Street provides access to the site. Major improvements are not likely required for construction and operation of the facility.
- The site is in the area with the second highest probability of soils good for infiltration. The remaining screening criteria are similar to other potential sites for Technical Feasibility.
- The site is similar to other potential sites for Environmental Impacts based on fine screening.

RECOMMENDATION:
Continue Evaluation in System Alternative Phase

Site Characteristics

Land Use and Acquisition

- The site is privately owned and is currently undeveloped forest. There is sufficient space for upland disposal facilities.
- The site is zoned Rural Area, Residential. A Special Use Permit is required if upland discharge of treatment plant effluent is defined as a wastewater treatment plant function. Development of upland discharge facilities is unlikely to affect economic development of the site.

Geographic Location

- The site is in an isolated, rural area and is not visible to nearby residences since sufficient buffer is likely available. Therefore, substantial screening or architectural treatments are probably not required.
- NE 24th Street provides access to the site. Increased traffic during construction and operation of the treatment plant is expected to have minimal impact on circulation in this area.
- Infrastructure such as electricity and water is not readily available at the site and would need to routed from the nearest available location.

Technical Feasibility

- There is no known contamination on the site.

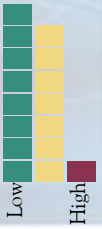
Environmental Impacts

- There are no known impacts to shorelines, sensitive areas, wetlands or endangered species at this time. Additional information should be collected to determine if there are any potential environmental impacts.
- Depending on the exact location of the facility, the footprint may fall within 1,000 feet of a water well. Additional mitigation measures may be required to protect the well.

SITE SUMMARY

Geographic Location: Unincorporated King County (Southeast of City of Carnation)
Estimated Total Area: 19.9 acres
Owner: Private Property
Current Use: Vacant

Fine Screening Impact Results:



King County

Upland Discharge
Site Fact Sheet
Option E
(Site No. 158)

Overall Site Description

- Located southeast of the City of Carnation in unincorporated King County. It is southeast of the closed City landfill.
- The closest current access road is NE 20th Street. NE 20th Street appears inadequate and major improvements would be required.
- The site has a slight slope to the southwest and includes second growth forest.

Screening Summary and Results

- The site ranked relatively high for *Land Use Compatibility and Acquisition* since:
  - The site is privately owned and is currently undeveloped second growth forest. There is sufficient space for upland disposal facilities.
- The site ranked slightly lower for *Geographic Location* since:
  - The site is in an isolated, rural area and is not visible to nearby residences. Therefore, substantial screening or architectural treatment is probably not required.
  - However, the existing access roads are inadequate. Major improvements would be required for construction and operation of the facility.
- The site is in the area with the second highest probability of soils good for infiltration. The remaining screening criteria are similar to other potential sites for *Technical Feasibility*.
- The site is similar to other potential sites for *Environmental Impacts* based on fine screening.

RECOMMENDATION:
Continue Evaluation in System Alternative Phase

Site Characteristics

Land Use and Acquisition

- The site is privately owned and is currently undeveloped second growth forest. There is sufficient space for upland disposal facilities.
- The site is zoned Rural Area, Residential. A Special Use Permit is required if upland discharge of treatment plant effluent is defined as a wastewater treatment plant function. Development of upland discharge facilities is unlikely to affect economic development of the site.

Geographic Location

- The site is in an isolated, rural area and is not visible to nearby residences. Therefore, substantial screening or architectural treatment is probably not required.
- The existing access roads to the site are inadequate. Major improvements would be required for construction and operation of the facility.
- Infrastructure such as electricity and water is not readily available at the site and would need to routed from the nearest available location.

Technical Feasibility

- There is no known contamination on the site.

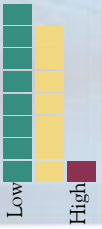
Environmental Impacts

- There are no known impacts to shorelines, sensitive areas, wetlands or endangered species at this time. Additional information should be collected to determine if there are any potential environmental impacts.
- Depending on the exact location of the facility, the footprint may fall within 2,000 feet of a water well. Additional mitigation measures may be required to protect the well.

SITE SUMMARY

Geographic Location: Unincorporated King County (Southeast of City of Carnation)
Estimated Total Area: 159.4 acres
Owner: Private Property
Current Use: Vacant

Fine Screening Impact Results:



King County

Car603fsSite158-6620.indd 6/30/03

King County Department of Natural Resources and Parks
Upland Disposal Alternatives

TECHNICAL MEMORANDUM 5

DRAFT
April 2003

1218 THIRD AVENUE, SUITE 1600 ? SEATTLE, WASHINGTON 98101? (206) 684-6532 ? FAX (206) 903-0419

King County Department of Natural Resources and Parks

Upland Disposal Alternatives

Technical Memorandum 5

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TECHNICAL MEMORANDUM 5
UPLAND DISPOSAL ALTERNATIVES

1.0 INTRODUCTION

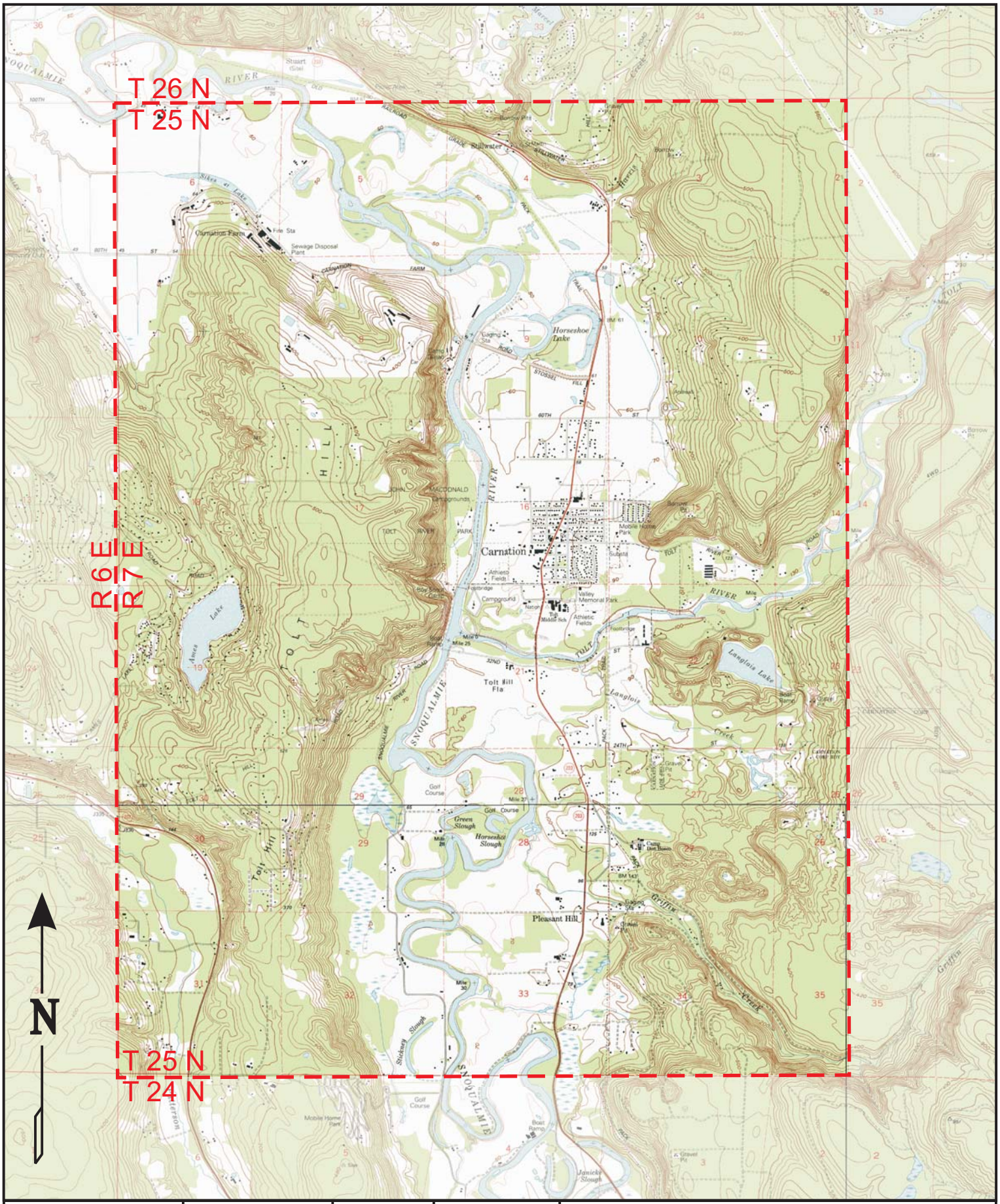
Technical Memorandum 5 discusses the potential for disposing of reclaimed water from the proposed Carnation Wastewater Treatment Facility (CWWTF) on upland areas instead of through an outfall directly to the Snoqualmie River. This work is being completed as part of preliminary studies, concerning the (CWWTF) conducted by a consultant team headed by Carollo Engineers. The application of reclaimed water on upland areas as a method of disposal carries several advantages with respect to the water resources of the region and the environment in general as compared to an outfall in the rivers. As part of the consultant team Robinson & Noble was tasked with the responsibility of performing a reconnaissance level investigation of an area within a 2.5-mile radius of Carnation to determine the feasibility of upland disposal and to identify, if possible, candidate areas for such application of the reclaimed water. A map of the study area is presented as Figure 1.

2.0 APPROACH AND PROCEDURES

The feasibility study and the investigation of possible candidate sites involved regional evaluations of soil types and distribution, land ownership, and hydrogeologic settings. These evaluations included the development of physical criteria that if met would facilitate infiltration of reclaimed water without adverse impacts. The primary adverse impact considered in the criteria development was groundwater flooding, either directly at a potential infiltration site or downgradient from a site.

The initial effort was to acquire soils, geologic and hydrologic information to characterize the study area. Additionally, a GIS (as well as soils and other information) data base containing land ownership and a parcel information of the study area was accessed. Preliminary evaluations were made regarding minimum realistic infiltration rates, the maximum practical slope for an infiltration facility, and realistic safety factors to provide constraining project criteria for soil type geology, hydrogeologic setting and topography. Analyzing the criteria allowed for the definition of the minimum practical parcel size for the proposed application in areas of favorable soils and geology. Minimum parcel size was based upon the assumption that infiltration would be the sole means of disposal. Should infiltration be combined with reuse as a disposal method (irrigation for example), allowable parcel size may be smaller. Key assumptions used in the development of the criteria included:

- Infiltration will be required year-round
- to provide for rehabilitation during operation, a minimum of two infiltration basins are necessary per site.
- The infiltration facility will need to dispose of the projected, maximum daily flow at build out of 0.93 mgd as determined by draft Technical Memorandum 2.



ROBINSON & NOBLE, INC.	Note: Basemap Taken from USGS Carnation and Fall City Quads	PM: JEB April 2003 R&N Job No. 1200-001A	T 25 N/R 7 E King County April 2003 Scale 1" = 4000'	Figure 1 **Study Area and Vicinity Map** Carnation Wastewater Treatment Facility, King County Dept. of Natural Resources and Parks

?? Only scientific factors were considered

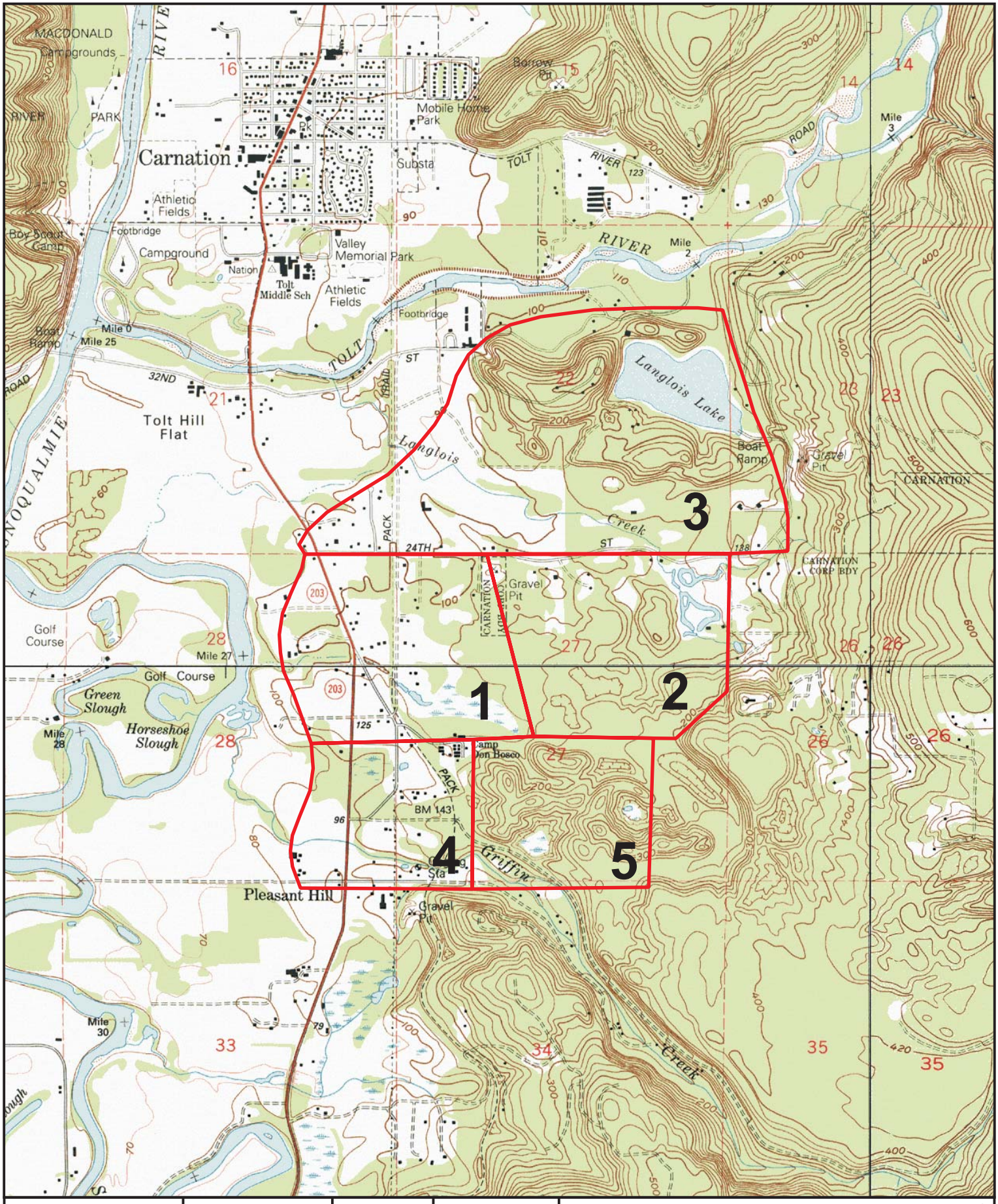
Parcels that are large enough and exhibit appropriate soils, infiltration characteristics and topography were sorted and identified using GIS techniques. Areas in which potentially qualified parcels exist were subjected to local and regional hydrogeologic evaluations to address the likely fate of water introduced through infiltration facilities. Areas were eliminated from further consideration if the fate analysis indicated potential adverse impacts. Information for each of the possible candidate sites which passed the fate analysis was then entered into a matrix to rate each site's suitability for further consideration. A map showing the most suitable parcels was generated and narrative summaries of the characteristics and suitability of the five best candidate areas were generated.

3.0 CANDIDATE AREA SELECTION

Several parcels where the desired application of reclaimed water might be accomplished were identified by the process described above. All of these identified parcels are located in the area south and southeast of the City of Carnation. To facilitate further evaluation, following the identification of specific parcels, clusters of parcels were grouped into five zones. The location of these five zones is shown in Figure 2. Subsequent evaluations of the hydrogeologic setting and characteristics of each of these zones are discussed in Section 4.

The process of assessing suitability of specific areas for infiltration of reclaimed water from the CWWTF required that planned application rates and a minimum site size be established. Based upon the projected maximum daily flow at buildout as reported in Draft Technical Memorandum 2 and an initial review of the soils map, the geomorphology, and the hydrogeology, it was determined that a ten-acre minimum facility size should be used in the search for possible sites. This facility size presumes that two infiltration ponds of approximately five acres each will be required in order to allow for maintenance on one pond while the other is in service. The pond size has been estimated as a function of the acceptable infiltration rates of area soils, projected maximum daily the application rate envisioned for the facility, and a safety factor applied to account for typical reductions in infiltration rate (from initial pre-construction pre-operational soil rates) that occur within operating infiltration basins. A safety factor of 20 was used for this evaluation.

Potential infiltration sites were initially located using soils information in the 1973 United States Department of Agriculture Soil Survey for King County. A soil infiltration rate of at least 0.63 in/hr was determined to be necessary to handle the proposed quantities of water generated by CWWTF. A number of soil types in the area meet or exceed this infiltration rate, however, reported seasonal water tables at or near land surface eliminated several soil types from further consideration. For infiltration to be most effective, an unsaturated zone needs to exist between the base of an infiltration basin and the water table, a situation not likely with a high water table. A final selection of three soil types were determined to have infiltration rates higher than 0.63 in/hr and seasonal water levels low enough low enough to potentially allow the proposed infiltration. The three acceptable soil types are Everett gravelly sandy loam or 0%-5% slopes (EvB), Everett gravelly sandy loam or 5-15% slopes (EvC), and the Ragnar-Indiaola association,



ROBINSON & NOBLE, INC.	Note: Basemap Taken from USGS Carnation and Fall City Quads	PM: JEB April 2003 R&N Job No. 1200-001A	T 25 N/R 7 E King County April 2003 Scale 1" = 2000'	Figure 2 **Potentially Favorable Infiltration Zones** Carnation Wastewater Treatment Facility, King County Dept. of Natural Resources and Parks

(RdC). Using ArcView, and data provided by Carollo Engineers, areas with the three acceptable soil types were identified and mapped. Utilizing GIS techniques, it was determined that 524 parcels in the study area (from a total of 3,289) contain areas with the acceptable soils.

The three selected soil types are generally associated with recessional glacial outwash. As is discussed in Section 4, the surface geology of much of the area south and southeast of the City of Carnation is Vashon Recessional Outwash. The high permeability of the sands and gravels which typically make up glacial outwash, make it an ideal unit for the application of reclaimed water.

Because of the potential for uncontrolled flooding, and thus the loss of infiltration capacity, locations within the 100-year floodplain were determined to be unsuitable. As discussed above the assumed, minimum acceptable site size is ten acres. After removing all parcels on the floodplain and all parcels less than ten acres in size, the potentially acceptable site list was pared down to 124.

To further narrow the potential sites, the 124 parcels were further characterized by their topography. The average slope of each parcel was calculated using 20-foot contour information within the GIS database. Sites with slopes greater than 10% were eliminated. This provided a final list of 14 potentially acceptable parcels, which is presented in Table 3.1. Each of the 14 parcels have some significant portion of their area within the previously determined zone of suitable soils, are not in the floodplain, have slopes of less than 10%, and are at least 10 acres in size.

Table 3.1 List of Parcels within the Proposed Zones of Infiltration

PARCEL I.D. #	MATRIX RSULTS	SECTION	QUARTER SECTION	LOT SQFT	LOT ACRE	ZONE
2725079007	13	27	NW	1018306	23.38	1
2825079001	12.5	28	NE	501376	11.51	1
2725079039	12	27	SW	1213581	27.86	4
2725079008	12	27	NW	871200	20.00	1,2
2725079005	11.5	27	NW	484822	11.13	1,2
2225079016	11.5	22	SW	5089550	116.84	3
2825079024	11.5	28	SE	599821	13.77	4
2725079028	11	27	NW	871200	20.00	2
2725079045	10	27	NE	837659	19.23	2
2725079002	10	27	NE	865537	19.87	2
2325079024	9.5	23	SW	497890	11.43	3
2825079033	9	28	SE	987069	22.66	4
2225079001	8.5	22	NE	15376680	353.00	3
2725079010	8.5	27	NE	7544592	173.20	4,5

Note: All parcels located in Township 25N, Range 7E

The final list of 14 parcels was then evaluated with regard to the ability of the hydrogeologic system to accept and transport infiltrated water. This analysis of the ultimate fate of any infiltrated water was necessary to determine the potential for adverse impacts at distance from the infiltration site. This analysis is based upon the area's hydrogeologic setting and a conceptual model of the groundwater flow system as described in Section 4 below. It appears

that the ultimate fate of the ground water in the area containing the 14 parcels, as well as any reclaimed water added to the ground water, is to the Snoqualmie river either directly as baseflow or via the Tolt River (again as baseflow). While the fate of the water appears to be acceptable in all 14 parcels, a geologic feature in the center of the upland area (an apparent, subsurface rise in low permeability sediments) makes areas closer to the Snoqualmie River somewhat more desirable than those farther to the east.

The key characteristics of the 14 parcels were input to a weighted matrix and the relative suitability of each was determined. Each of the selection factors for an individual parcel was examined and given a ranking of 1, 2 or 3 (with 3 being the most favorable for infiltration). The factors used in the matrix were: soil infiltration rate, slope, sub-surface permeability, implied fate of applied water, and parcel size. Parcel size was deemed less critical than the other factors and, therefore, given only half the weight of the other factors in the matrix (ranking of 0.5, 1 or 1.5) Rankings for each factor were summed to give a composite score for each of the parcels.

These scores are relative and because site-specific studies have not been performed on the parcels, any particular parcel may be found, in reality, to be unsuitable once subjected to proper field investigation. Prior to final consideration for infiltration, selected parcels must be examined on a close-order scale with performance of appropriate field testing to define the specific infiltration characteristics of the site. Because any individual parcel identified through this process may not actually be acceptable when examined more closely, the parcels were divided into the five zones with similar characteristics. These zones are presented on Figure 2. A few of the parcels have portions within more than one zone. Each of the five zones is described in greater detail in Section 5.

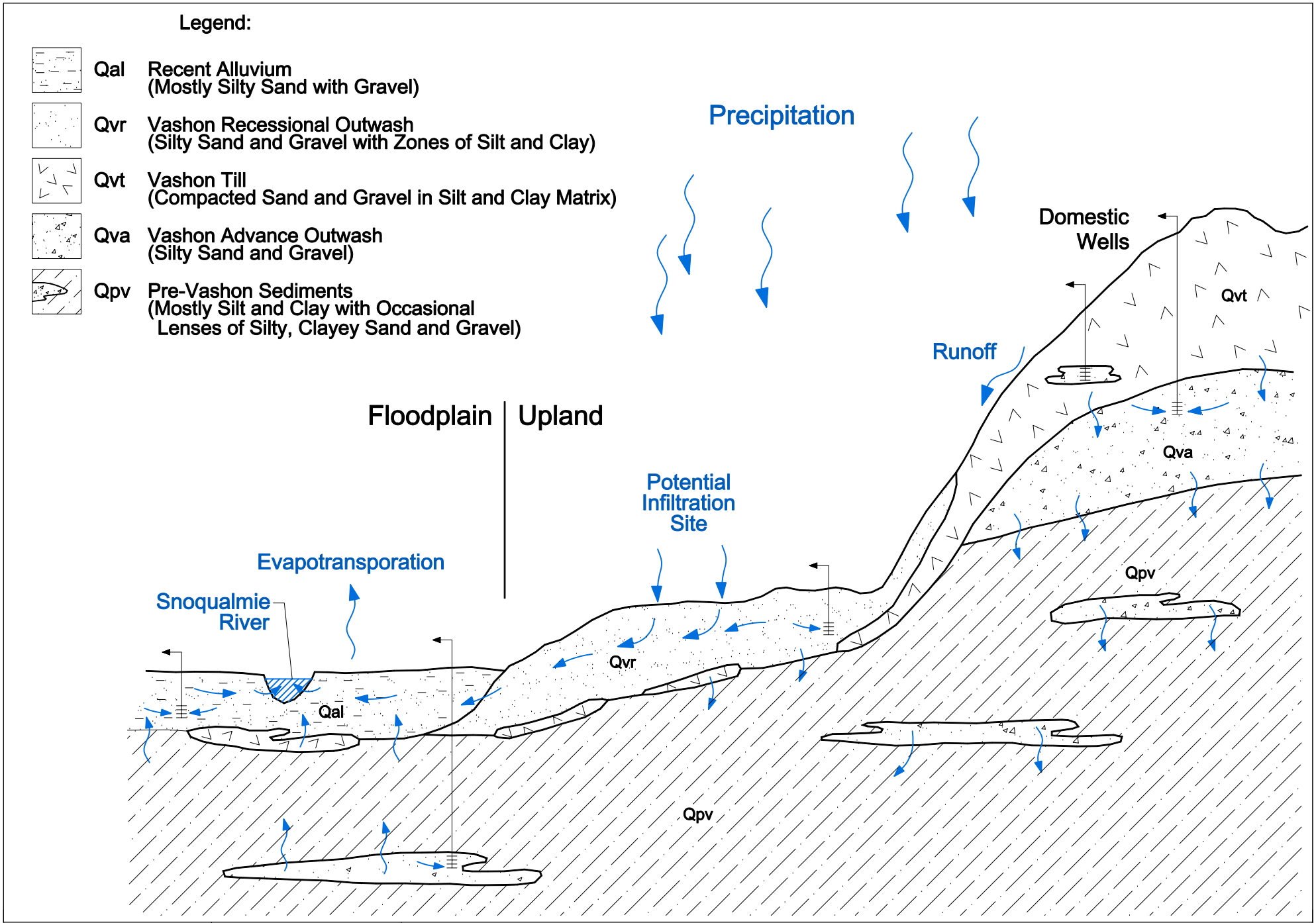
4.0 HYDROGEOLOGIC SETTING

To evaluate the subsurface conditions within the area of interest, a series of hydrogeologic cross-sections were constructed. Cross-sections were constructed using published geologic maps and reports, and information contained in State Water Well Reports (well logs) on file with the Washington State Department of Ecology (Ecology). A conceptual model to describe general groundwater flow system was developed based largely on the information provided by the cross sections. The conceptual model is presented as a conceptual cross section as Figure 3.

4.1 Regional Setting

The Snoqualmie River Valley, and specifically Carnation, are situated near the eastern edge of the Puget Sound Lowland. This regional-scale basin is generally trough-shaped and trends approximately north-south between the Olympic and Cascade Mountain Ranges. Throughout the Pleistocene, continental glaciers advancing southward from Canada, repeatedly inundated the region, resulting in the deposition of a thick, alternating sequence of glacial and interglacial sediments. Generally this sequence is thickest near the center of the basin (in excess of 2,000 feet in portions of Kitsap and Pierce Counties) and thins toward the margins. Within the study area, Tertiary-age bedrock is interpreted to occur between 200 and 400 feet below the surface and crops out at the surface less than three miles to the east (Turney and others, 1995).[1]

[1] Turney, G.L. and others, 1995, Geohydrology and Ground-water quality of East King county, U.S. Geological Survey water-Resources Investigations Report 94-4082, 123 p, 4 plates.



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April 2003
Drawing Not to Scale
R&N Job No. 1200-001A

Figure 3
Conceptual Cross Section Potentially Favorable Areas South of Carnation
Carnation Wasterwater Treatment Facility, King County Dept. of Natural Resources and Parks

Geologic units present at effective depths within the study area are comprised exclusively of unconsolidated sediments, which are subdivided into three general groups. From youngest to oldest, these include, 1) recent alluvium associated with local rivers, 2) deposits of the Vashon Glaciation, and 3) pre-Vashon non-glacial or transitional deposits.

Recent alluvium (Qal) includes fluvial materials deposited on present-day floodplains and adjacent to the major streams in the area. These deposits occur primarily within the floodplains of the Snoqualmie and Tolt Rivers, but also include less prevalent deposits adjacent to smaller streams such as Griffin and Langlois Creeks. Grain size, and associated permeability, of the Qal is variable within the study area, ranging from low permeability clay and silt in floodplain deposits, to coarser, high permeability sand and gravel in deposits more closely associated with stream channels.

Vashon glacial deposits generally include the extensive sequence of glacial material deposited in the Puget Sound Lowland during the Vashon Stade of the Fraser Glaciation. Locally, these deposits represent the latest glacial advance and are comprised of three distinct subunits. These are, from oldest to youngest, advance outwash (Qva), till (Qvt), and recessional outwash (Qvr) as mapped by Turney.

Advance outwash includes deposits laid down by meltwater issuing from the advancing Vashon Glacier. It is typically comprised of well sorted sand and gravel with variable amounts of silt. Because it was overridden by the advancing glacier, it is usually compacted. Advance outwash is generally moderately to highly permeable, and is a locally utilized aquifer for a number of domestic wells in the Carnation area. Within the study area, advance outwash is generally constrained to the uplands surrounding the Snoqualmie Valley flood plain.

Till deposits consist of a variable percentage of sand and gravel within a clay- to sand-size matrix. Because till was deposited in-situ by the glacier and not transported by meltwater, deposits are generally poorly sorted. Like the advance sediments, it is typical for till deposits to have been compacted by the weight of the overriding glacier. As such, deposits are usually highly impermeable and acts to constrain groundwater flow. The thickest till deposits found in the area generally form caps on the tops of the hills in the higher upland areas. However, thin till-like deposits (likely lodgment till deposited directly below the advancing glacier) are indicated by well logs to be present within the shallow subsurface below the floodplain and lower portions of some in the project area.

Recessional outwash includes material deposited generally by meltwater issuing from the receding Vashon Glacier. Locally, this includes coarser materials laid down by meltwater streams as well as finer material deposited in lakes or other still-water environments formed by or associated with the receding glacier. By nature of the depositional mechanism in the study area (i.e. stagnating ice melting in place), the recessional deposits tend to be less sorted than the advance deposits within the primary area of interest. As they were not overridden by the glacier, they tend to be significantly less compacted. Generally, the recessional deposits are moderately to highly permeable in comparison to the underling till. Within the lower portions of the upland area (east of the Snoqualmie floodplain) recessional outwash accounts for much of the surficial geology, and ranges in thickness from a thin veneer to several hundred feet.

Pre-Vashon interglacial or transitional deposits (Qpv) are the oldest sediments identified in the study area. The majority of these deposits, as indicated in well logs, consist of thick sequences

of lower permeability silts and clays with much thinner, discontinuous lenses of sand and gravel. At least some portion of the upper section of this unit likely represents deposition in a pro-glacial lake associated with the Vashon Glacier. The deeper (older) portion of the formation, though, is certainly representative of an interglacial depositional environment, probably similar to the current Snoqualmie River floodplain. The transition point between the glacial and interglacial deposits, is not easily discernable. Regardless, the generally fine-grained nature of the unit indicates that it functions as an aquitard in the regional hydrogeology. This means that, like the till, this unit impedes the vertical movement of ground water. In this setting the unit inhibits the movement of ground water from the Vashon outwash sediments to deeper groundwater regimes.

4.2 Conceptual Model

A hydrogeologic conceptual model is a graphic representation of a groundwater flow system. It is often used to simplify and organize information about the various components of the water flow systems so that it can be more readily analyzed (Anderson and Woessner, 1992).[2] Ideally, the conceptual model should be as simple as possible, yet contain every important hydrologic component necessary to describe system behavior. Conceptual models can be a precursory to some form of computer modeling. However, for this project, the conceptual model is utilized to describe the likely fate of water that might be introduced into the subsurface by the infiltration facilities being considered. It is also used here to help guide decisions regarding potential areas where infiltration of reclaimed water might be feasible.

The five zones identified as potential infiltration sites are all situated within the lower portion of the upland areas immediately east of the Snoqualmie Valley floodplain and south of the Tolt Valley floodplain (Figure 2). The conceptual model, presented on Figure 3, as a conceptual cross section, shows the general flow components of this area. It is intended to describe how ground water moves through the hydrologic system of this specific area, from sources of recharge to points of discharge. The surface geology within all five of the identified zones is dominated by recessional outwash and its related soil types. The recessional deposits are, in turn, underlain in this area by thin, possibly discontinuous till deposits. These are, in turn underlain by the pre-Vashon silt and clay deposits. Well logs examined for wells in this area indicate that the Vashon advance deposits are locally absent. As such, whether the till in this area is discontinuous or not is not a critical factor with regard to the function of the conceptual model because both the till and the pre-Vashon deposits act similarly to impede vertical groundwater flow.

As illustrated in Figure 3, recharge to this area occurs primarily through direct precipitation. Precipitation typically infiltrates quickly into the subsurface in areas where recessional outwash is at the surface (given the permeable nature of the recessional deposits and its associated soils). Additional recharge to the recessional outwash covered area is also derived from surface runoff and shallow subsurface flow moving down gradient from higher elevations (both also derived from precipitation). Initially, the major component of infiltrating water moves vertically downward through the recessional materials until it reaches the base of the unit. Once the water encounters the lower permeability till and clay units (Qvt and Qpv), it saturates the recessional sediments until it has generated a sufficient gradient to cause the water to flow laterally through the more permeable sediments down gradient to the floodplain area, and eventually discharging

[2] Anderson, M.P. and Woessner, W.W., 1992, Applied groundwater modeling simulation of flow and advective transport, Academic Press, Inc., 381 p.

to either the Tolt or Snoqualmie Rivers. Some small portion of the ground water is likely to leak vertically downward into the less permeable underlying units, particularly at the higher elevations (recharge zones), but this component is likely relatively minor and is not expected to be a significant factor within the context of this study. Additionally, some small portion of ground water will be discharged from the system by domestic wells in this area. Again, these are likely a minor component and the preponderance of ground water flowing through the shallow system in this area will discharge to the Snoqualmie River, either directly as base flow or via base flow to the Tolt River.

Reclaimed water from the proposed CWWTF, if applied in the potentially favorable areas identified, should act very similarly to naturally occurring ground water. The water should infiltrate through the recessional outwash to the water table and then eventually flow down gradient to the floodplain and ultimately the rivers.

5.0 DISCUSSION

Fourteen individual parcels were selected and ranked as being potentially acceptable for the proposed infiltration. Because no site-specific work has been completed on these sites, the rankings given are relative and with site-specific investigations, any particular parcel may be found not to be suitable. Because under closer-order investigations particular sites may not be suitable, the parcels were divided into areas, or zones, where the likelihood of finding a suitable site is high. Five such zones were delineated and are described below.

5.1 Zone 1

Zone 1 is located within Township 25N, Range 7E in the NE quarter of section 28 and the NW quarter of section 27. The soils in most of the zone are mapped as RdC which has an infiltration rate of 2.0 to 6.3 in/hr. According to the USGS topographic maps, which cover the area, a small portion of the SW quarter of the NW quarter of section 27 is mapped as a marsh. The zone slopes gently to the west toward the Snoqualmie River. The western boundary of the zone follows closely to the boundary of the 100-year floodplain. Cross sections drawn for this project suggest that locally the Qvr deposits are thick enough to accommodate the proposed infiltration rate. Well log evidence suggest Vashon till occurs locally in thin deposits below the recessional outwash at depths of 50 to 70 feet. Once the infiltrated water reaches the shallow groundwater system its ultimate fate is likely the Snoqualmie River as baseflow. Two identified parcels are located completely within zone 1, and another two are partially within zone 2.

5.2 Zone 2

Zone 2, which is directly east of zone 1, lies completely within section 27. Much of this zone is relatively flat (some hills along the southeastern edge of the zone have a gentle slope to the west). Approximately 85% of the surface in zone 2 is mapped with EvC type soil; which is listed as having an infiltration rate of 6.3 to 20 in/hr. Surface geology is mapped throughout the zone as Qvr. Small ponds located in the NE corner of zone 2 occur because of local, less permeable soils then those throughout the rest of the zone. Three identified parcels are completely within this zone, with two more sharing a portion of zone 1. All the parcels shown within this zone meet the criteria set forth in this study, however, some local portions of the zone, most notably the area of the ponds, fail to meet suitable infiltration rates. A review of local well logs suggests a thin intermittent layer of till at 60 to 80 feet below land surface. However, along the eastern

boundary of the zone the till appears to form a “mound” or possibly a ridge. If this higher elevation zone of till is laterally extensive, it may form an impediment to the down-gradient movement of infiltrated water, and perhaps induce ponding at or near land surface. Conversely, it is possible the till mound may not extend laterally, and would allow groundwater flow to bypass it all together. Without a proper understanding of the lateral extent of this feature, it is not possible to determine what effect it may have on any planned infiltration project within this zone.

5.3 Zone 3

Zone 3 is the largest of the five zones. It is located within the southern half of section 22, along with the SW quarter of the SW quarter of section 23, and much of the SE quarter of section 21. Much of the zone is mapped as having EvC and EvB soils, each with infiltration rates of 6.3 to 20 in/hr. Local geology is mapped as Qvr. A review of local well logs suggests the underlying till is at a depth 40 to 60 feet. Infiltrated water may either flow directly to the west, eventually reaching the Snoqualmie River, or it may flow in a northwesterly direction in which case it will most likely reach the Tolt River first. Zone 3 contains a large area that exhibits a high slope which would not be suitable for the proposed infiltration. The zone contains three parcels identified by the study as potentially acceptable.

5.4 Zone 4

Zone 4 is located directly south of zone 1 within section 28 and 27. Approximately 60% of the zone is mapped as containing suitable soils. The zone has a gentle slope to the west towards the Snoqualmie River. This zone contains some soils that were not classified as being favorable during this study. Application, should it occur within this zone, should be limited to the areas containing the favorably identified soils to avoid ponding of the reclaimed water. Evaluation of the subsurface geology suggests that groundwater from zone 4 likely flows to the Snoqualmie River. Three full parcels and one partial parcel (shared with zone 5) have been identified as potentially acceptable within zone 4.

5.5 Zone 5

Zone 5 is located within section 27. The zone is dominated by steep slopes which make much of the zone unacceptable. Additionally, much of the zone is not mapped as having acceptable soils. However, the remaining portions of the zone contain Everett gravelly sandy loam 15% to 30% slope (EvD). Though this soil type was not selected due to its presence in steep uneven areas; it does have an acceptably high predicted infiltration rate. If a sufficiently large, flat area can be found within this zone, that has the EvD soil type, infiltration may be possible. Geology maps show the area as Qvr, and Geologic cross sections suggests the possibility of a thin intermittent layer of till sloping to the west at a depth of 60 to 80 feet. Infiltrated water is likely to flow westerly through the shallow sediments, ultimately reaching the Snoqualmie River as base flow. This zone contains only a portion of one of the 14 identified parcels.

6.0 REGULATORY CONSIDERATIONS

The infiltration of highly treated effluent from the CWWTF must meet the requirements of Department of Ecology groundwater quality standards as set into law by 90.46, 90.48, and 90.54 RCW and reflected in WAC 173-200, and 173-154. These regulations require that the water not be rendered unable to serve the beneficial uses it is currently serving nor that its quality be degraded from its current condition. Though the regulation is an anti-degradation standard, very little change in groundwater quality is tolerated at the point of compliance. The point of compliance for infiltrated water is expected to be the water table at the down-gradient side of the site where the infiltrated water leaves the control of the project. However, the point of compliance for each particular project is defined by Ecology (WAC 173-200-060) after a "Groundwater Evaluation Program" (WAC 173-200-080) has been completed. Ecology is the lead agency with regulatory authority over infiltration facilities; the Department of Health performs a review of project documentation.

The clear intent of state law is that no beneficial function or potential beneficial function of the ground water of the state be lost due to degraded groundwater quality. Class A treatment is likely to be the minimum standard for delivery of water to an infiltration facility. Further, it is likely that additional reduction of nitrate will be required as well. For infiltration to be used, a complete hydrogeologic characterization of the project site will be required as part of the facilities plan or project engineering report. The nature of this evaluation and subsequent required groundwater monitoring is dependent upon the specific site conditions and will be defined by Ecology at the time the project is established for consideration. However, monitoring of groundwater quality will be necessary prior to the design and permitting of the facility, and further will be required during operation of the infiltration facility.

No local ordinances were identified in this present study that relate to the groundwater quality aspects of proposed infiltration within the zones identified above. However, to place an infiltration facility within the areas identified herein, County zoning issues may need to be resolved. Additionally, geotechnical implications of a given facility may involve evaluation under County ordinances enforced by King County Department of Development Services (DDS).

Overall, this investigation did not identify any reason to conclude that the five zones discussed above would be inherently unable to conform with the regulatory constraints on the infiltration of reclaimed water.